

# The Periodic Table: Chemical Periodicity

## Question Paper 2

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	The Periodic Table: Chemical Periodicity
<b>Sub-Topic</b>	
<b>Paper Type</b>	Multiple Choice
<b>Booklet</b>	Question Paper 2

**Time Allowed:** 50 minutes

**Score:** /41

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

**Section A**

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 The value of the second ionisation energy of calcium is  $1150 \text{ kJ mol}^{-1}$ .

Which equation correctly represents this statement?

- A**  $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^{-}; \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$   
**B**  $\text{Ca}^{+}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^{-}; \Delta H^{\ominus} = +1150 \text{ kJ mol}^{-1}$   
**C**  $\text{Ca}^{+}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^{-}; \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$   
**D**  $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^{-}; \Delta H^{\ominus} = -1150 \text{ kJ mol}^{-1}$

- 2 In which species does the underlined atom have an incomplete outer shell?

- A**  $\underline{\text{Al}}_2\text{Cl}_6$       **B**  $\underline{\text{C}}\text{H}_3^{+}$       **C**  $\text{Cl}_2\underline{\text{O}}$       **D**  $\text{H}_2\underline{\text{Cl}}\text{Cl}\cdot$

- 3 The period 4 elements gallium (Ga), germanium (Ge), arsenic (As) and selenium (Se) are the elements below aluminium, silicon, phosphorus and sulfur in the Periodic Table, a portion of which is shown below.

period 3 elements	Al	Si	P	S
period 4 elements	Ga	Ge	As	Se

The properties of each period 4 element resemble those of the period 3 element directly above it.

Which period 4 elements form oxides that dissolve in water to give an acid solution?

- A** As and Se      **B** Ga and Ge      **C** Ga and Se      **D** Se only

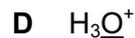
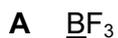
4 Use of the Data Booklet is relevant to this question.

Sodium and sulfur react together to form sodium sulfide,  $\text{Na}_2\text{S}$ .

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
<b>A</b>	sodium > sulfur	sodium > sulfur
<b>B</b>	sodium > sulfur	sodium < sulfur
<b>C</b>	sodium < sulfur	sodium > sulfur
<b>D</b>	sodium < sulfur	sodium < sulfur

5 In which species does the underlined atom have an incomplete outer shell?



6 The oxides  $\text{BaO}$ ,  $\text{CaO}$ ,  $\text{MgO}$  and  $\text{SrO}$  all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?



7 Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

**A** A chloride ion has one more occupied electron shell than a sodium ion.

**B** Chlorine has a higher proton number than sodium.

**C** Ionic radius increases regularly across the third period.

**D** Sodium is a metal, chlorine is a non-metal.

8 Elements **X** and **Y** are both in period three.

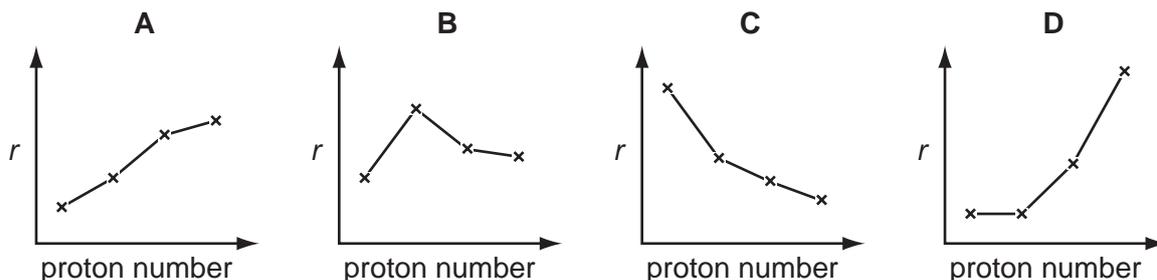
When the chloride of **X** is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of **Y** is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

- A Both chlorides hydrolyse in water.
- B **X** is phosphorus and **Y** is aluminium.
- C **X** is silicon and **Y** is sodium.
- D **X** is sodium and **Y** is phosphorus.

9 Which diagram shows the variation of the metallic radius  $r$  of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



10 The table gives the successive ionisation energies for an element **X**.

	1st	2nd	3rd	4th	5th	6th
ionisation energy / $\text{kJ mol}^{-1}$	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of **X**?

- A  $\text{XCl}$
- B  $\text{XCl}_2$
- C  $\text{XCl}_3$
- D  $\text{XCl}_4$

11 During steel-making the impurity  $\text{P}_4\text{O}_{10}$  is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate,  $\text{Ca}_3(\text{PO}_4)_2$ .

In this reaction, how many moles of calcium oxide react with one mole of  $\text{P}_4\text{O}_{10}$ ?

- A 1
- B 1.5
- C 3
- D 6

12 Use of the Data Booklet is relevant to this question.

Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

- A Ionic radius always decreases with increasing atomic number.
- B Positive ions have smaller radii than negative ions.
- C The potassium ion has more protons in its nucleus than the sulfide ion.
- D The sulfide ion is doubly charged; the potassium ion is singly charged.

13 Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is  $\text{Fe}^{2+}$  and one anion which is  $\text{SO}_4^{2-}$ .

The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

A grey-green solid residue was also formed which was insoluble in water.

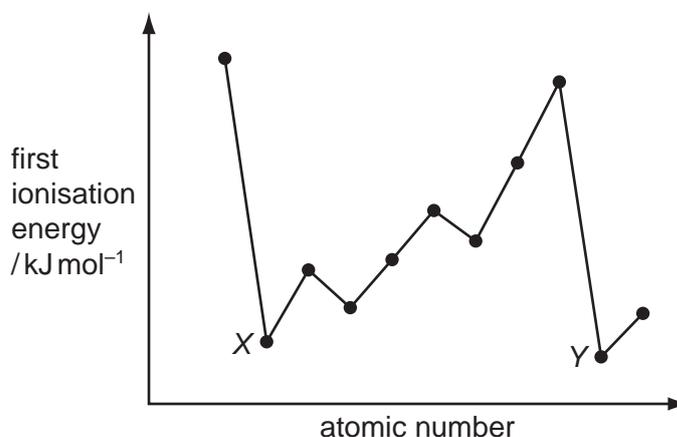
What are the identities of the gas and the solid residue?

	gas	residue
A	$\text{NH}_3$	$\text{Fe}(\text{OH})_2$
B	$\text{NH}_3$	$\text{Na}_2\text{SO}_4$
C	$\text{SO}_2$	$\text{Fe}(\text{OH})_2$
D	$\text{SO}_2$	$\text{Na}_2\text{SO}_4$

14 Which oxide, when mixed with water, will produce the solution with the lowest pH?

- A  $\text{CO}_2$
- B  $\text{Na}_2\text{O}$
- C  $\text{P}_4\text{O}_{10}$
- D  $\text{SiO}_2$

- 15 Which equation represents the second ionisation energy of an element X?
- A**  $X(g) \rightarrow X^{2+}(g) + 2e^{-}$
- B**  $X^{+}(g) \rightarrow X^{2+}(g) + e^{-}$
- C**  $X(g) + 2e^{-} \rightarrow X^{2-}(g)$
- D**  $X^{-}(g) + e^{-} \rightarrow X^{2-}(g)$
- 16 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?
- A** The nuclear charge of the elements increases.
- B** The outer electron is in an 's' subshell.
- C** The repulsion between spin-paired electrons increases.
- D** The shielding effect of the inner shells increases.
- 17 The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled X and Y?

- A** Group I metals
- B** Group II metals
- C** halogens
- D** noble gases

- 18 Why does aluminium oxide dissolve in sodium hydroxide solution?
- A Aluminium oxide can behave as a base.
  - B Aluminium oxide can behave as an acid.
  - C Aluminium oxide has a giant structure.
  - D The bonding in aluminium oxide is ionic.
- 19 Concentrated sulfuric acid can behave **both** as a strong acid **and** as an oxidising agent.
- With which compound does concentrated sulfuric acid react in this way?
- A ethanol
  - B magnesium carbonate
  - C propanenitrile
  - D sodium bromide
- 20 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?
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  - B The outer electron is in an 's' subshell.
  - C The repulsion between spin-paired electrons increases.
  - D The shielding effect of the inner shells increases.

21 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp/°C	801	2852	3550
bp/°C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
<b>A</b>	MgO	NaCl	C [graphite]
<b>B</b>	MgO	NaCl	SiO <sub>2</sub>
<b>C</b>	NaCl	MgO	C [graphite]
<b>D</b>	NaCl	MgO	SiO <sub>2</sub>

22 Three elements, X, Y and Z, have the physical properties shown in the table.

element	melting point /°C	boiling point /°C	density /g cm <sup>-3</sup>
<b>X</b>	-7	59	3.12
<b>Y</b>	98	883	0.97
<b>Z</b>	649	1107	1.74

What could be the identities of X, Y and Z?

	X	Y	Z
<b>A</b>	Br <sub>2</sub>	Al	Si
<b>B</b>	Br <sub>2</sub>	Na	Mg
<b>C</b>	I <sub>2</sub>	Mg	Na
<b>D</b>	I <sub>2</sub>	Si	K

23 Three compounds have the physical properties shown in the table.

compound	P	Q	R
melting point/°C	2852	993	-119
boiling point/°C	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

	P	Q	R
<b>A</b>	MgO	KCl	NH <sub>3</sub>
<b>B</b>	MgO	NaF	C <sub>2</sub> H <sub>5</sub> Br
<b>C</b>	SiO <sub>2</sub>	KCl	C <sub>2</sub> H <sub>5</sub> Br
<b>D</b>	SiO <sub>2</sub>	NaF	HCl

24 Ar, Ca<sup>2+</sup> and K<sup>+</sup>, contain the same number of electrons.

In which order do their radii increase?

	smallest radius	→	largest radius
<b>A</b>	Ar		Ca <sup>2+</sup>
<b>B</b>	Ca <sup>2+</sup>		K <sup>+</sup>
<b>C</b>	Ca <sup>2+</sup>		Ar
<b>D</b>	K <sup>+</sup>		Ca <sup>2+</sup>

25 Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic	→	most endothermic
<b>A</b>	Fr	Ra	Rn
<b>B</b>	Fr	Rn	Ra
<b>C</b>	Ra	Fr	Rn
<b>D</b>	Rn	Ra	Fr

26 Consecutive elements X, Y, Z are in the third period of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point.

What could be the identities of X, Y and Z?

- A** aluminium, silicon, phosphorus
- B** magnesium, aluminium, silicon
- C** silicon, phosphorus, sulfur
- D** sodium, magnesium, aluminium

27 Two properties of non-metallic elements and their atoms are as follows.

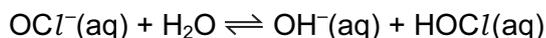
property 1 has an oxide that can form a strong acid in water

property 2 has **no** paired 3p electrons

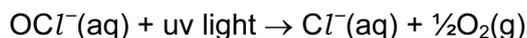
Which properties do phosphorus and sulfur have?

	phosphorus	sulfur
<b>A</b>	1 and 2	1 only
<b>B</b>	1 only	1 and 2
<b>C</b>	1 and 2	1 and 2
<b>D</b>	2 only	1 only

- 28 Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I),  $\text{NaOCl}$ . This reacts with water to produce  $\text{HOCl}$  molecules which kill bacteria.



In bright sunshine, the  $\text{OCl}^-$  ion is broken down by ultra-violet light.



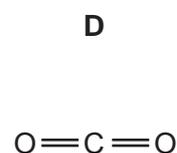
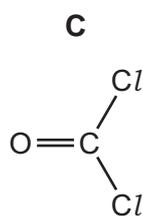
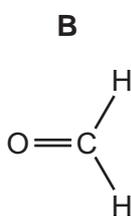
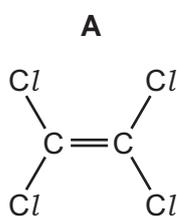
Which method would maintain the highest concentration of  $\text{HOCl}(\text{aq})$ ?

- A acidify the pool water
  - B add a solution of chloride ions
  - C add a solution of hydroxide ions
  - D bubble air through the water
- 29 How does concentrated sulfuric acid behave when it reacts with sodium chloride?
- A as an acid only
  - B as an acid and oxidising agent
  - C as an oxidising agent only
  - D as a reducing agent only
- 30 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?
- A A phosphorus atom has one more proton in its nucleus.
  - B The atomic radius of a phosphorus atom is greater.
  - C The outer electron in a phosphorus atom is more shielded.
  - D The outer electron in a phosphorus atom is paired.

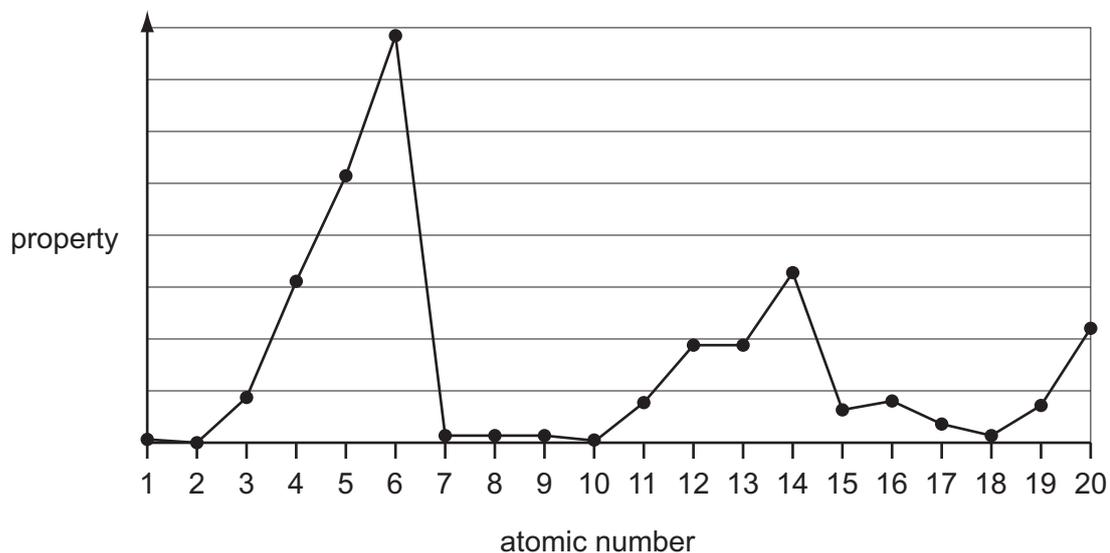
31 Which group of particles is in order of increasing size?

- A N O F
- B  $\text{N}^{3-}$   $\text{O}^{2-}$   $\text{F}^-$
- C  $\text{Na}^+$   $\text{Mg}^{2+}$   $\text{Al}^{3+}$
- D  $\text{Na}^+$  Ne  $\text{F}^-$

32 Which molecule has the largest overall dipole?



33 The following graph shows the variation of a property of the first 20 elements in the Periodic Table with the atomic number of the element.



What is the property?

- A atomic radius
- B first ionisation energy
- C ionic radius
- D melting point

**Section B**

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
<b>1, 2 and 3</b> are correct	<b>1 and 2</b> only are correct	<b>2 and 3</b> only are correct	<b>1 only</b> is correct

No other combination of statements is used as a correct response.

34 When added to water, which oxides will **not** cause a change in pH?

- 1  $Al_2O_3$
- 2  $SiO_2$
- 3  $P_4O_{10}$

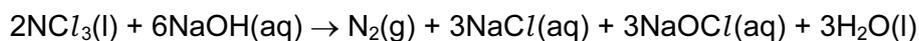
35 Which statements are correct?

- 1 Aluminium chloride dissolves in water to give an acidic solution.
- 2 Magnesium chloride dissolves in water to give a slightly acidic solution.
- 3 Sodium chloride dissolves in water to give an alkaline solution.

36 Which oxides react with water to give a solution of pH 10 or higher?

- 1 CaO
- 2  $Na_2O$
- 3 SrO

- 37 When the yellow liquid  $\text{NCl}_3$  is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.



What will be the result of this reaction?

- 1 The nitrogen undergoes a redox reaction.
  - 2 A bleaching solution remains after the reaction.
  - 3 The final solution gives a precipitate with acidified silver nitrate.
- 38 Which statements are correct?
- 1 Aluminium chloride dissolves in water to give an acidic solution.
  - 2 Magnesium chloride dissolves in water to give a slightly acidic solution.
  - 3 Sodium chloride dissolves in water to give an alkaline solution.
- 39 The definitions of many chemical terms can be illustrated by chemical equations.
- Which terms can be illustrated by an equation that shows the formation of a positive ion?
- 1 first ionisation energy
  - 2 heterolytic fission
  - 3 enthalpy change of atomisation
- 40 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

- 1 Molecule Y has lone pairs of electrons.
- 2 The atmospheric oxidation of Y to Z is a catalysed reaction.
- 3 Y is a colourless gas.

- 41 On a scale in which the mass of a  $^{12}\text{C}$  atom is 12 the relative molecular mass of a particular sample of chlorine is 72.

Which properties of the atoms in this sample are always the same?

- 1 radius
- 2 nucleon number
- 3 isotopic mass